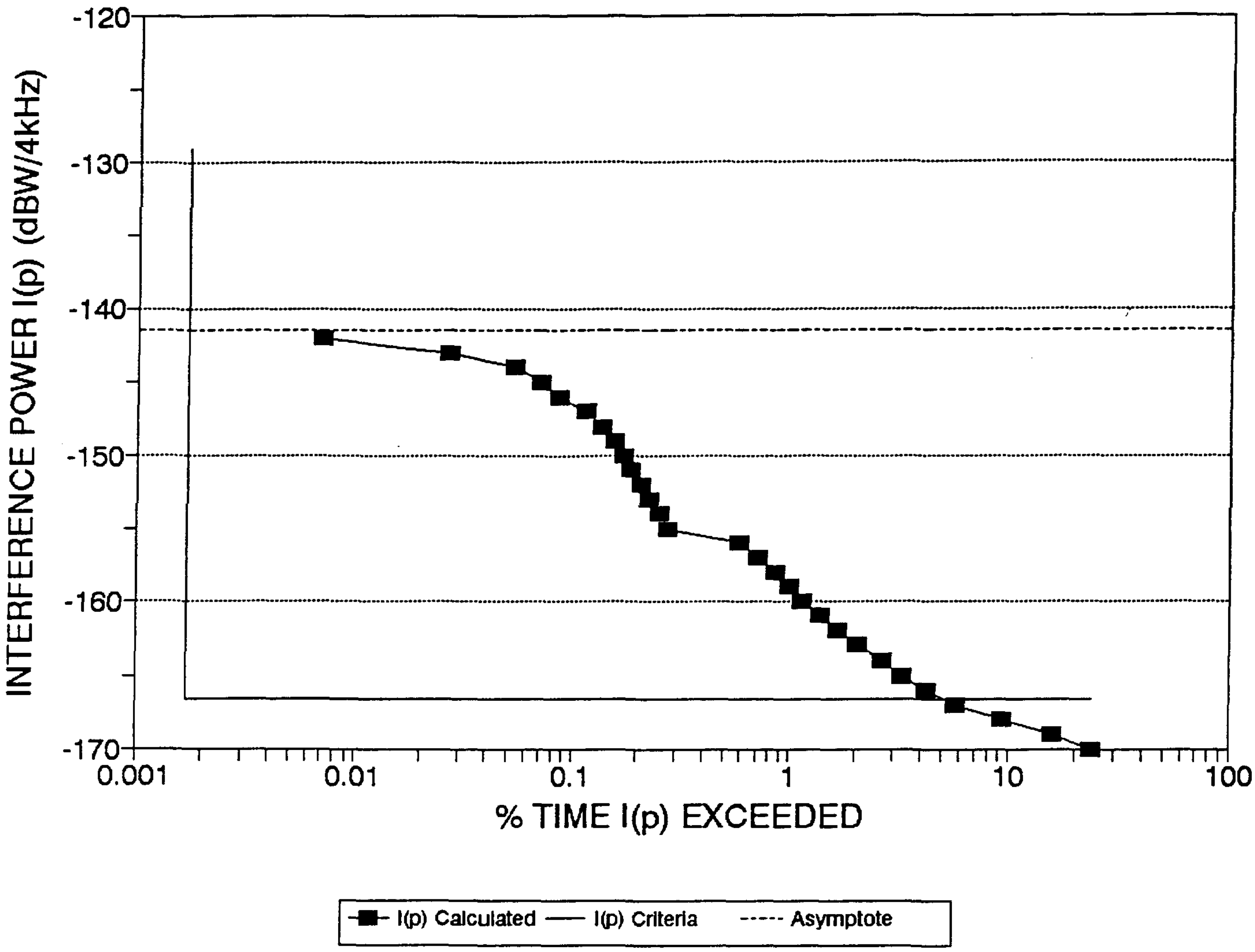

Figure 2. Comparison of Permissible Interference With Interference Caused By Operation of Loral MSS Satellites at the PFD Limit of RR 2566

Notes:

1. The victim fixed station is located at 40° North latitude with a mainbeam azimuth of 143° and antenna gain of 40 dBi.

2. The computer simulation addressed one day of operation and performed interference calculations at intervals of 0.01 minute.

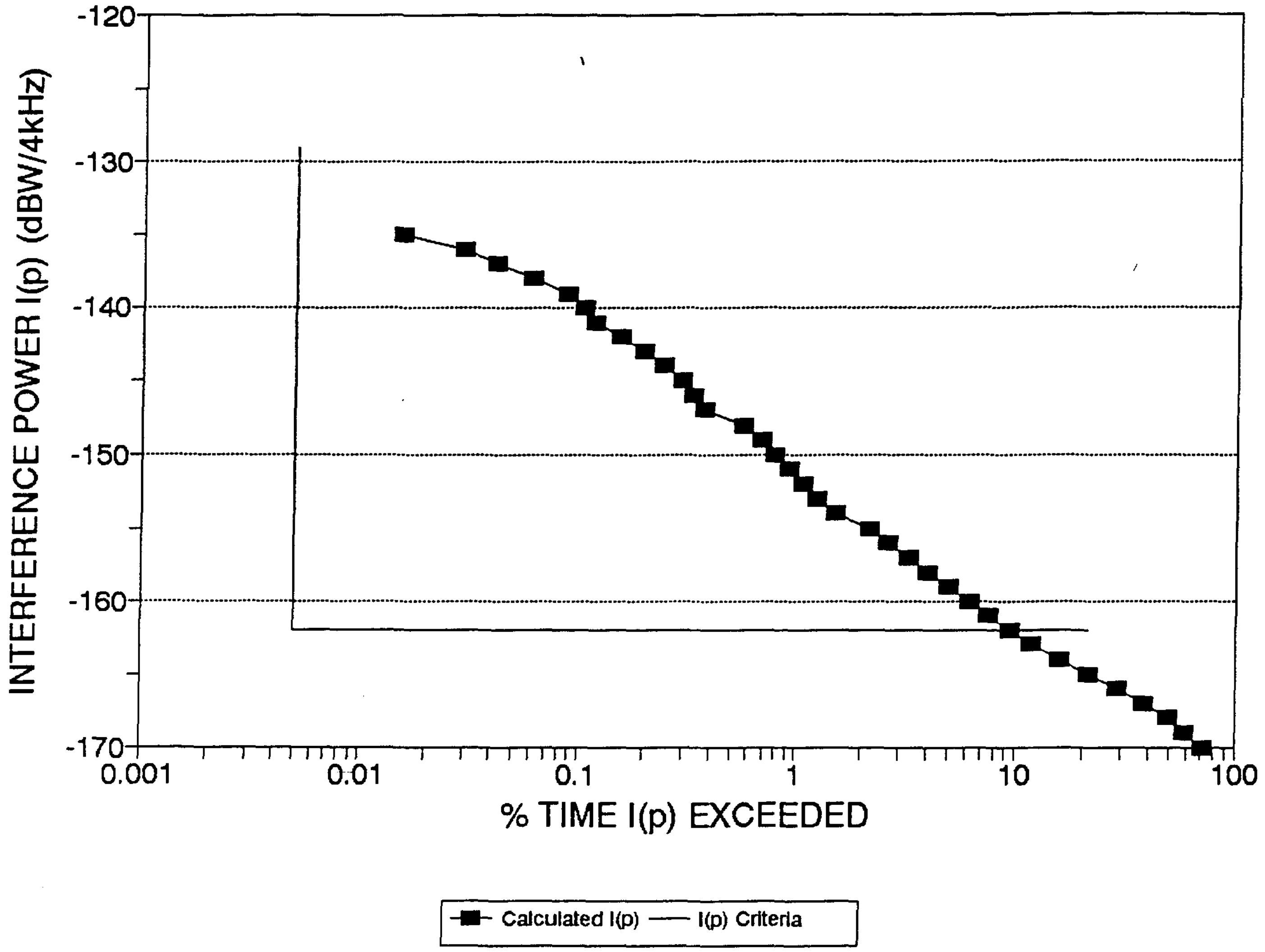

Figure 3. Comparison of Permissible Interference With Interference Caused By Operation of TRW and Loral MSS Satellites at the PFD Limit of RR 2566

Notes:

1. The victim fixed station is located at 25° North latitude with a mainbeam azimuth of 53° and antenna gain of 40 dBi.

2. The computer simulation addressed five days of operation and performed interference calculations at intervals of 0.01 minute.

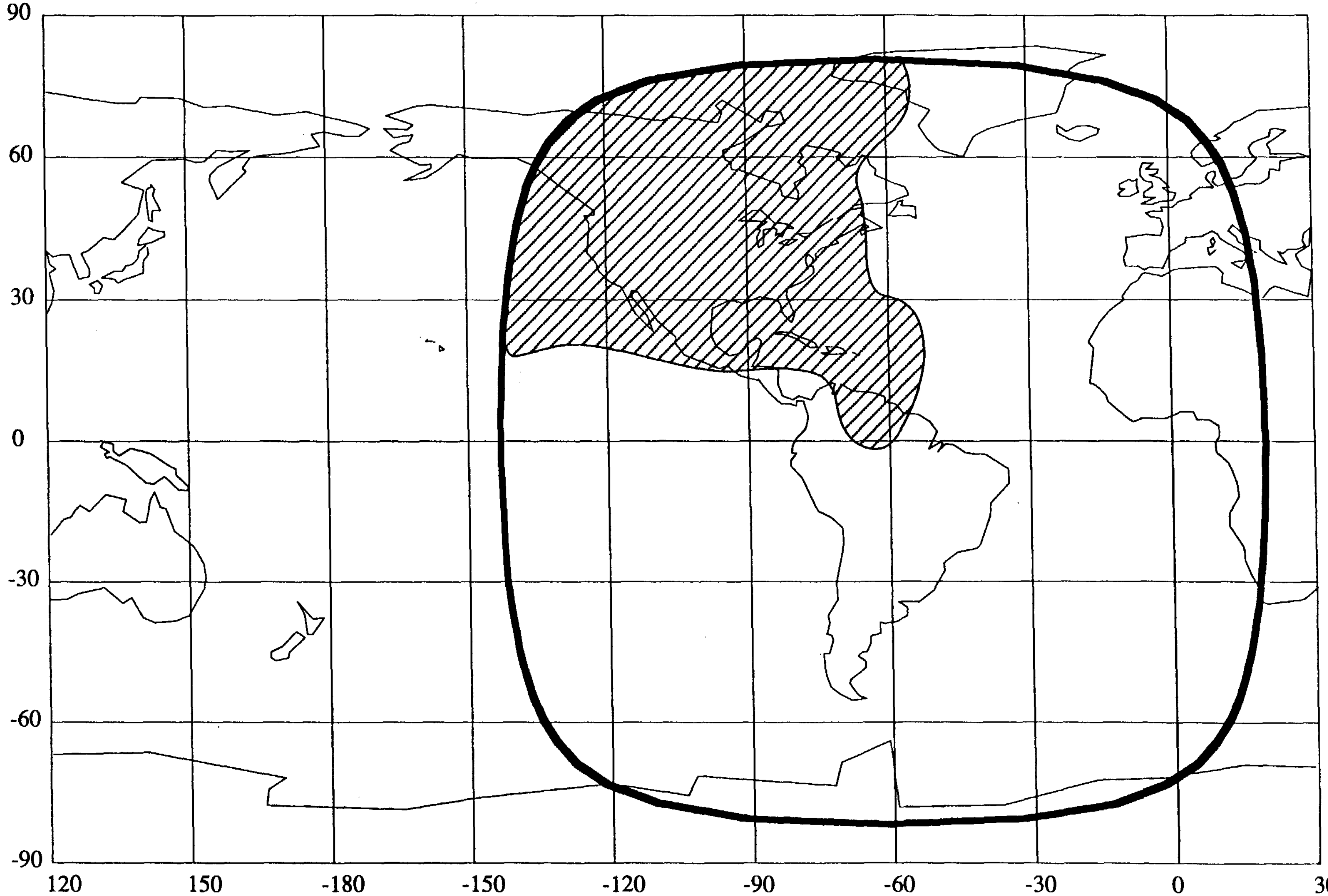

Figure 4. Area Where AMSC's Downlink Operations at 2483.5-2500 MHz Could Exceed the RR 2566 Threshold (Cross-Hatched Area)

ANNEX TO TECHNICAL APPENDIX

Documents
CCIR Study Groups
Period 1990-1994

Document USSG 8D/36 (Rev. 1)
2 December 1992
Original: English

UNITED STATES OF AMERICA

DRAFT NEW REPORT

E.I.R.P. LIMITS FOR TRANSMITTING SATELLITES IN THE 1613.8-1626.5 MHz BAND NEEDED FOR PROTECTION OF RECEIVING SATELLITES

(Question 83/8)

1. Introduction

WARC-92 allocated the band 1613.8-1626.5 MHz to the Mobile Satellite Service (MSS) in the Earth-to-space direction on a primary basis and in the space-to-Earth direction on a secondary basis. CCIR studies of the sharing criteria for this band are invited by Resolution 46 (COM5/8) adopted by WARC-92. Because MSS downlinks in the 1613.8-1626.5 MHz band are allocated on a secondary basis, they are not entitled to coordination with respect to MSS uplinks; thus, guidelines are needed on how the MSS downlinks can avoid causing harmful interference. This Report provides preliminary guidance on equivalent isotropically radiated power (e.i.r.p.) limits that should be observed in the 1613.8-1626.5 MHz band by low-Earth-orbit (LEO) satellites in MSS (space-to-Earth) networks in order to prevent harmful interference to MSS (Earth-to-space) networks. Further study is needed in order to develop a complete set of guidelines.

2. Basis for e.i.r.p. limits

Radio Regulation (RR) 2548A specifies an e.i.r.p. limit of -3 dBW/4 kHz for earth stations operating in the Radiodetermination Satellite Service (RDSS), and that e.i.r.p. density is specified under RR 731X as a special coordination trigger for MSS earth stations. That e.i.r.p. density can be used as the basis for certain equivalent e.i.r.p. limits for transmitting satellites. Given that several secondary MSS downlinks may simultaneously interfere with a primary MSS or RDSS uplink, interference from MSS downlinks should be substantially less than the interference from an MSS or RDSS uplink in order to prevent harmful interference. Accordingly, insofar as an uplink e.i.r.p. density of -3 dBW/4 kHz corresponds with the permissible single entry value of interference at the satellite, the equivalent Earth-based e.i.r.p. from a transmitting satellite should be less than -18 dBW/4 kHz. This will ensure that the interfering signal power generated by several secondary MSS downlinks will not cause harmful interference when added to the interfering signal power generated by primary interferers.

Use of Earth-based equivalent e.i.r.p. density as the basis for satellite e.i.r.p. limits is valid for situations where the transmitting satellite is located in a conical volume subtended by the Earth, the vertex of which is a receiving satellite. That is, the interfering signals are propagating along Earth-to-space signal paths in this model. Figure 1 illustrates the applicable geometries. Further study is needed for cases where the receiving satellite is located between Earth and the transmitting satellite, particularly with regard to the backlobe characteristics of receiving satellite antennas and requirements for protecting receivers located on Earth and operating in other services. Further study is also needed of the potential for interference via Earth backscatter of the downlink signals. In addition, interactions between transmitting and receiving geostationary satellites are not encompassed in the Earth-based equivalent e.i.r.p. approach.

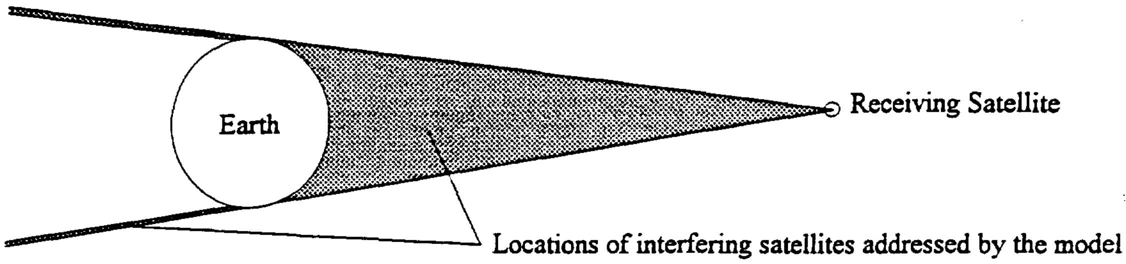

Figure 1. Geometric limits for relating satellite e.i.r.p. to mobile earth station e.i.r.p

3. Analysis

The satellite e.i.r.p. value that is equivalent to an Earth-based e.i.r.p. value can be determined from the difference (in dB) between free space losses on the path between the receiving satellite and the Earth (i.e., the path that pertains to the mobile earth station e.i.r.p. limit) and the direct path between satellites, as in equation 1. Because the direct path may be shorter than the path between the receiving satellite and Earth, the satellite e.i.r.p. in certain directions will have to be less than the Earth-based equivalent e.i.r.p. Equation 1 permits calculation of the satellite e.i.r.p. density limits.

$$E(\_) < E' - \{32.45 + 20 \log [f] + 20 \log [R1]\} + \{32.45 + 20 \log [f] + 20 \log [Rlos(\_)]\} \qquad (1a)$$

$$E(\_) < E' - 20 \log [R1/Rlos] \qquad (1b)$$

where:

E(_): satellite e.i.r.p. density limit (dBW/4 kHz) at an off-nadir angle _;

_: off-nadir angle measured at the transmitting satellite (degrees);

E': Earth-based e.i.r.p. density limit (-18 dBW/4 kHz);

f: frequency (MHz);

R1: path length (km) between the receiving satellite and Earth;

Rlos(_): path length (km) between the transmitting satellite and the receiving satellite in the direction of the off-nadir angle _.

3.1 E.I.R.P. limit in the direction of an Earth tangent

For the near-antipodal situation illustrated in Figure 2, R1 is measured along an Earth tangent and Rlos (distance between transmitting and receiving satellites) is equal to the sum of R1 and R2 (distance between the transmitting satellite and Earth along an Earth tangent). A realistic maximum value for the ratio R1/Rlos should be used in equation 1 in order to determine the limiting value of e.i.r.p. density. In this case, reception by a geostationary satellite yields an R1 value of 42,570 km and Rlos is slightly greater (LEO transmitting satellite), and so, the ratio R1/Rlos is slightly less than 1. Assuming a minimum transmitting LEO satellite altitude of about 700 km altitude, the ratio R1/Rlos is 0.82 (42,570/(42,570 + 9513). LEO-LEO interactions yield lower values for the ratio R1/Rlos (on the order of 0.5). Thus, the satellite e.i.r.p. in the direction of the Earth tangent should be limited as shown in equation 2.

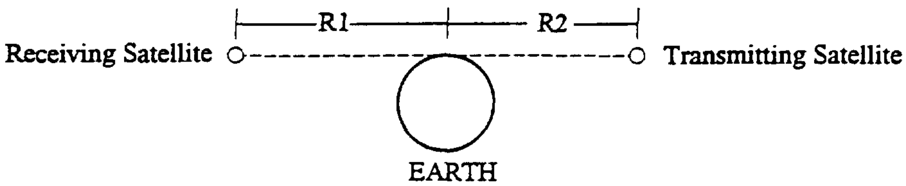

Figure 2. Geometry for "nearly antipodal"interference interactions

$$E(\_) < E' - 20 \log (42{,}570/52083) \quad (2a)$$

$$E(\_) < E' + 1.7 \text{ dB} \quad (2b)$$

3.2 <u>E.I.R.P. limit in the satellite backlobe directions</u>

Figure 3 illustrates the geometry for the case where interference may occur from transmitting satellite backlobe emissions. The limiting value of satellite e.i.r.p. density is determined in equation 1 using a suitable maximum value for the ratio R1/Rlos. For a geostationary receiving satellite and LEO transmitting satellite, R1/Rlos is slightly greater than 1, which is not a realistic maximum value for the ratio. For the case where a LEO receiving satellite is located at nadir from the transmitting satellite, a minimum collision avoidance distance of 50 km can be assumed for Rlos and R1 can be approximated by the altitude of the transmitting satellite (h). Thus, with these assumptions, satellite e.i.r.p. in the direction opposite nadir would be limited as shown in equation 3.

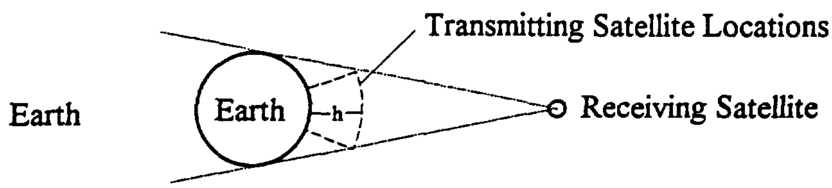

Figure 3. Geometry for interference interactions involving transmitting satellite backlobes.

$$E(180) < E' - 20 \log [h/50] \quad (3a)$$

$$E(180) < E' + 34 - 20 \log [h] \quad (3b)$$

where h is the altitude of the transmitting satellite.

3.3 Summary of derived satellite e.i.r.p. limits

Based on the principal that satellite e.i.r.p. density in the band 1613.8-1626.5 MHz should not exceed an equivalent Earth-based value of -18 dBW/ 4 kHz, the following satellite e.i.r.p. density values should not be exceeded:

- -16.7 dBW/4 kHz, in any direction along an Earth tangent;

- 16 - 20 log (h), in the direction opposite nadir, for a satellite operating at an altitude *of h* (km).

DECLARATION

I, Thomas M. Sullivan, do hereby declare as follows:

1. I have a Bachelor of Science degree in Electrical Engineering and have taken numerous post-graduate courses in Physics and Electrical Engineering.

2. I am presently employed by Atlantic Research Corporation and was formerly employed by the IIT Research Institute, DoD Electromagnetic Compatibility Analysis Center.

3. I am qualified to evaluate the foregoing Comments of AMSC Subsidiary Corporation. I am familiar with Part 25 and other relevant parts of the Commission's Rules and Regulations.

4. I have participated in the development of standards and criteria for space and terrestrial services in the CCIR for over fifteen (15) years.

5. I served as Technical Advisor to the U.S. Delegation to WARC-92 and participated in sessions of WARC-92 addressing frequency sharing and other technical matters.

6. I have been involved in the preparation of and have reviewed the foregoing Comments of AMSC Subsidiary Corporation and the Technical Appendix thereto. The technical facts contained therein are accurate to the best of my knowledge and belief.

Under penalty of perjury, the foregoing is true and correct.

December 4, 1992
Date

Thomas M. Sullivan
Thomas M. Sullivan

CERTIFICATE OF SERVICE

I, Valerie A. Mack, a secretary in the law firm of Fisher, Wayland, Cooper and Leader, hereby certify that true copies of the foregoing "Comments of AMSC Subsidiary Corporation" were sent this 4th day of December, 1992, by first class United States mail, postage prepaid, to the following:

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